pacing can be successfully achieved in more than 70% of DCM pts. New lead technology should probably result in significantly better success rate in the near future.

1045-111 Feasibility of Measuring the "Optimal Atrioventricular Delay"

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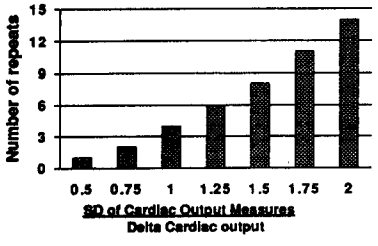
Individual programming of the atrioventricular delay (AVD) has been suggested to be useful, especially in patients with heart failure. However, a single measurement of the best AVD may be unreliable because of variability in cardiac output (CO). To determine the feasibility of measuring the optimal AVD, we calculated the number of times measurements would have to be repeated to achieve a 90% probability of finding the true optimal value. Probabilities were found by computer simulation of 25000 hypothetical pts with normal random variation. 5 AVDs were tested with uniformly spaced true mean CO. The figure shows the number of repeats required which depends on the ratio of standard deviation (SD) of repeat measures of CO *to* the change in CO with a change in AV interval. In 13 pts with pacemakers, tested on 3 occasions a week apart, the SD of Doppler CO was 359 ml and the change in CO with a 25 ms change in AVD was 212 ml (307 ml for a 50 ms change in AVD). Thus, in this example, measurements would need to be repeated on > 10 separate occasions to be reasonably certain of finding the best AVD within 25 ms and 6 times to find the best AVD within 50 ms.



Thus, a precise determination of the optimal AVD is impracticable in most pts because the change in CO as the AVD changes is less than the variability in CO measurement.

1045-112 Minute Ventilation during Submaximal Exercise: Influence on Respiratory Driven Rate Adaptive Pacing

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Detection of minute ventilation (VE) by intrathoracic impedance changes has been established in rate adaptive pacemakers. During initiation of exercise, it is known that other devices e.g. muscle activity driven pacemakers may generate a faster paced heart rate response. The objective of this study was to analyze whether the kinetics of minute ventilation (VE) offer, in combination with the kinetics of respiratory rate (RR) and tidal volume (Vt), the potential of a more prompt and normal response. *Methods:* 61 healthy normals (age 46 ± 16 ys) were exercise tested on a treadmill using the "Low Intensity Treadmill Exercise"- protocol (LITE). Respiratory parameters were collected "breath by breath" with a MedicalGraphics CPX/D system. Kinetics of VE, Vt and RR were determined by linear regression analysis at 20 sec and 30 sec after initiation of exercise and at steady state (STS). *Results:* 20 sec after initiation of exercise Vt increased up to 978 ± 325 ml (30% of the resting value) and after 30 sec to 1085 ± 405 ml (45%). The increase of RR after 20 sec was lower: 19.5 ± 6.7 breaths/min (19%) and after 30 sec 19.5 ± 6.3 breaths/min (18.9%). The increment to STS was 71% (1278 ± 521 ml, Vt) and 22% (19.8 ± 5.8 breaths/min, RR) corresponding to a dynamic increase of 285 ml/min (Vt) und 1.5 breaths/min (RR) from rest to STS. *Conclusions:* Tidal volume shows a more marked increase at the initiation of exercise than respiratory rate. Simultaneous detection of tidal volume kinetics and minute ventilation with a modified algorithm may offer better discrimination of the early exercise phase. Improved reactivity of a minute ventilation sensor may generate a faster paced heart rate response during daily submaximal exercise.

1045-113 Proposal for a Novel Minute Ventilation Based Rate Adaptive Pacing Algorithm

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Current 3rd generation minute ventilation (VE) based rate adaptive pacing algorithms require a complex biphasic linear slope programming in order to appropriately match metabolic demand and paced heart rate (HR). It was the purpose of this study to determine a mathematical expression of the HR to VE relationship allowing one to design a pacing algorithm which is more simple to program for the physician and still guarantees a high correlation to the normal sinus node's response to various intensity levels of activity. Eighty-four healthy adults (34 women and 50 men, mean age: 44 ± 16 yrs) were exercised on a treadmill with "breath-by-breath" gas exchange monitoring using the symptom limited "ramping incremental treadmill exercise" (RITE) protocol. The HR to VE relationship was analysed performing (1) a linear regression analysis from rest to anaerobic threshold (AT, slope A) and from AT to peak exercise (slope B), (2) a natural logarithmic (lnx) expression from rest to peak exercise and (3) a linear expression of the logarithmic transform (logtrnf) function for the HR or y-axis variable.

	Study group	Women	Men
HR/VE (A)	1.51 ± 0.44 (r: 0.92)	1.72 ± 0.38 (r: 0.92)	1.35 ± 0.42 (r: 0.93)
HR/VE (B)	1.04 ± 0.4 (r: 0.94)	1.2 ± 0.46 (r: 0.91)	0.94 ± 0.25 (r: 0.95)
lnxHR/VE	49.1 ± 9.5 (r: 0.96)	48.9 ± 10.0 (r: 0.96)	49.1 ± 9.1 (r: 0.97)
logtrnfHR/VE	0.4 ± 0.08 (r: 0.97)	0.4 ± 0.07 (r: 0.97)	0.41 ± 0.08 (r: 0.98)

The analysis of the HR to VE relationship throughout peak exercise using the lnx expression or the logarithmic transformation of the y-axis variable demonstrated the highest correlation coefficents among the calculations performed. A rate adaptive pacing algorithm using a logarithmic expression of HR to VE ratio instead of a linear coupling could generate a paced rate response to exercise which closely simulates the normal sinus node, independent of gender. Since the lnx and the linear slope of logtrnf HR to VE appropriately represent the HR to VE relationship during various work load levels, a future 4th generation pacing algorithm would no longer require a different rate response programming for different levels of activity.

1045-114 Oxygen Uptake Kinetics During Low-Intensity Exercise Testing: Relevance for Rate Adaptive Pacemaker Programming

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The pacemaker's response time and its rate response factor are known determinants of oxygen uptake (V02) and oxygen deficit during low-intensity exercise testing. The purpose of this study was to establish a normals data base for oxygen uptake kinetics as a guideline for the programming of rate adaptive pacemakers and to determine its relationship to V02 at anaerobic threshold (AT) and peak exercise. Sixty healthy subjects (23 women: 51.6 ± 20.4 yrs, 37 men: 42.2 ± 16.2 yrs) performed treadmill exercise with "breath-by-breath" gas exchange monitoring using (1) the "Low-Intensity Treadmill Exercise" (LITE) protocol for a submaximal work load level of 35 external watts and (2) the "Ramping Incremental Treadmill Exercise" (RITE) protocol for peak exercise testing. (1) LITE protocol: V02 at steady state (STS) was 1040.6 ± 146.9 ml indicating an increase of 838.3 ± 369.9 ml above resting levels. The "mean response time" (MRT) of V02 or the inverse of the rate constant for the rise in V02 prior to reaching STS levels was 35.1 ± 9.9 s with a mean 02 deficit of 418.3 ± 147.9 ml. The 02deficit/V02 uptake ratio during the dynamic phase times the time from rest to STS was 55 ± 17 s. (2) RITE protocol: V02-AT was 22.1 ± 5.7 ml/kg/min, heart rate (HR) at AT: 120.1 ± 13.6 bpm; V02-peak was 37.6 ± 10.7 ml/kg/min with a peak HR of 167.8 ± 19.3 bpm. The MRT and 02deficit/V02 time index were significantly correlated to V02-peak and V02-AT ($p < 0.01$ for both MRT and 02 deficit/V02 time index). Oxygen uptake kinetics may serve as a control data base for the assessment of different pacemakers' "rate response factors" or response times and their influence on oxygen uptake during low-intensity exercise. Since functional, aerobic capacity below the anaerobic threshold more likely represents daily life activities and the kinetics of V02 are significantly related to V02 at both anaerobic threshold and peak exercise, low-intensity exercise may provide a clinically useful correlate or even substitute to peak exercise testing.